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Social-Distancing Monitoring Using Portable Electronic Devices

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Abstract:

The coronavirus pandemic is an ongoing pandemic of coronavirus disease 2019 (COVID-19) caused by a virus. The virus is mainly spread through close contact and respiratory droplets produced when people cough or sneeze. Recommended measures to prevent the spread of the infection include maintaining social distancing. As a result of these recommendations, there is a need to monitor and maintain physical distance between people in real-time and alert people of any deviation from recommended distancing.

This publication describes systems and techniques for portable electronic devices, such as smartphones, tablets, smartglasses, and smartwatches, to measure and analyze the distance between a user and other people. For example, a portable electronic device can be used to detect potential deviations from recommended social distancing using a radar sensor. In aspects, the portable electronic device, using an on-device machine-learned model, evaluates measured data to generate appropriate alerts for the user.

Keywords:

Radar sensor, camera, wireless local area network, WAN, Wi-Fi, machine learning, machine-learned model, social distancing, physical distancing, separation, coronavirus, COVID-19, viral, pandemic, spread, flatten the curve.

Background:

The coronavirus pandemic is an ongoing pandemic of the coronavirus disease. Common symptoms of the disease include fever, cough, and shortness of breath. While the majority of cases result in mild symptoms, some infected persons progress to viral pneumonia and multi-organ failure. As of April 1, 2020, more than 932,000 cases of coronavirus have been reported in over 200 countries and territories, resulting in approximately 46,800 deaths. The virus is mainly spread through close contact and respiratory droplets produced when people cough or sneeze. Efforts to prevent the virus from spreading include travel restrictions, lockdowns, shelter-in-place orders, quarantines, and social distancing. In general, the recommendation is that all individuals stay at least six feet apart (or two meters) to minimize close contact between individuals and slow the spread of the virus. Because social distancing is not within society's normal routines, people may not realize that they are not adhering to healthcare-expert recommendations.

It is desirable to utilize portable electronic devices to provide users with real-time social-distancing alerts and assist them in maintaining an appropriate physical separation from others.

Description:

This publication describes systems and techniques to maintain social distancing and provide appropriate alerts to users. Portable electronic devices are mobile and ubiquitous with capabilities to detect and measure various forms of input data. These features make portable electronic devices good candidates to assess social distancing among individuals in real-time and help users reduce their exposure to the coronavirus disease.

Throughout this disclosure, examples are described where a portable electronic device (or applications thereon may analyze information (*e.g.*, images, location information, nearby networks) associated with a user. Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, applications, and/or features described herein may enable the collection of user information (*e.g.*, information about a user's social activities, a user's current location), and if the user is sent content and/or communications from a server. The portable electronic device can be configured only to use the information after the portable electronic device receives explicit permission from the user of the portable electronic device to use the data. For example, in situations where an application analyzes location data to provide social-distancing information, individual users may be provided with an opportunity to provide input to control whether an application can access and make use of the data. Further, individual users may have constant control over what applications can or cannot do with the information. In addition, information collected may be pre-treated in one or more ways before it is transferred, stored, or otherwise used, so that personally-identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user. In another example, a user's geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level) so that a particular location of a user cannot be determined. Thus, the user may have control over whether the information is collected about the user and the user's device, and how such information, if collected, may be used by the portable electronic device, an application, and/or a remote computing system.

Figure 1 illustrates an example of a portable electronic device that can measure and process social-distancing data.

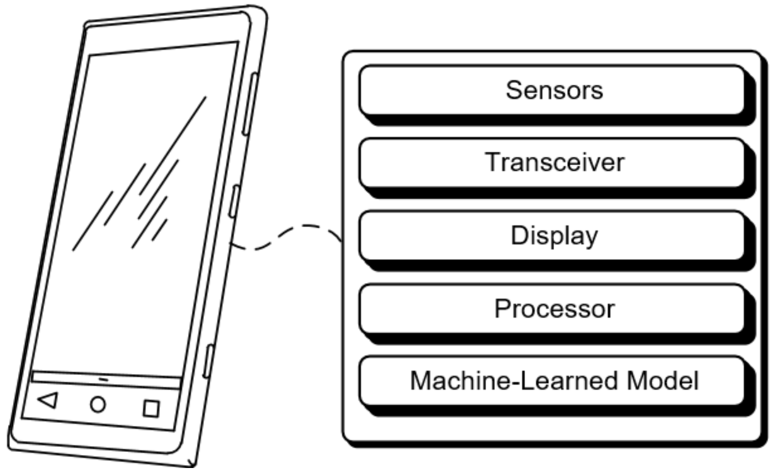

Figure 1

As illustrated in Figure 1, the portable electronic device can be a smartphone. The portable electronic device includes sensors, one or more transceivers for transmitting and receiving data over a wireless network, a processor, a display, and a machine-learned model. The sensors detect and measure a variety of input data. For example, the sensors can include a radar sensor, a camera, and a microphone.

A radar sensor can be used to detect simple gestures by the user in relation to a portable electronic device. The radar sensor emits electromagnetic waves and objects within its field-of-view reflect signals back to the portable electronic device. Based on the reflected signals, the radar sensor can determine how far away objects are and if the objects are moving relative to the portable electronic device. In this way, the radar sensor can determine if there are other persons nearby and whether social-distancing recommendations are being observed.

Cameras are standard features of portable electronic devices. Portable electronic devices generally include multiple cameras, with at least one front-facing camera and at least one rear-facing camera. Based on their fields-of-view, the cameras can detect and capture an image of the environment surrounding the portable electronic device. Many portable electronic devices also include a microphone, which converts nearby sound into an electrical signal.

Local data about the user's environment can be collected by the radar sensor and cameras. The portable electronic device can categorize the data using social-distancing classifications (*e.g.*, whether the user of the device is nearby, whether there are other individuals within a certain distance of the user) to train a machine-learned model. After sufficient training, the machine-learned model can be deployed to the operating system (OS) of the portable electronic device or an application of the portable electronic device. Figure 2 illustrates an example of how the OS or the application may use the local data and the machine-learned model to monitor social distancing.

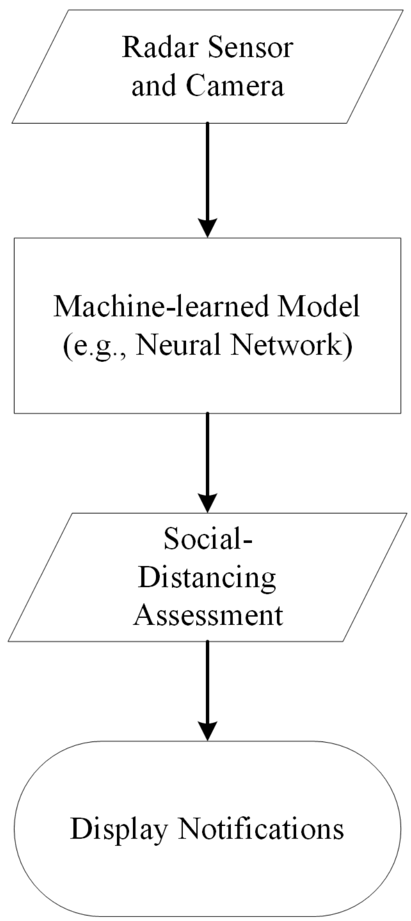

Figure 2

In Figure 2, the radar sensor periodically emits electromagnetic signals and generates a signal with data regarding nearby objects. For example, the user can activate social-distancing monitoring in an application (*e.g.*, a navigation application) or as a feature of the portable electronic device. The camera(s) on the portable electronic device can also periodically capture image data of the surrounding environment.

The machine-learned model receives the data and analyzes it for nearby objects. The machine-learned model uses algorithms to determine if a nearby detected object is the user, if other nearby detected objects include humans, and whether the distance between the user and other humans is in accordance with social-distancing guidelines.

The portable electronic device can also use electromagnetic signals (*e.g.*, wireless local area network (WLAN) signals) to assist in classifying nearby objects. WLAN signals, also commonly referred to as Wi-Fi signals, can be used to detect people in the vicinity of the portable electronic device, even through and around walls. In this way, Wi-Fi signals can be used to differentiate non-human objects, such as cars and buildings, from humans. In addition, size and speed data of nearby objects determined from radar and/or camera data can also be used to classify nearby objects. For example, the machine-learned model can be trained that fast-moving objects are vehicles. Similarly, the machine-learned model can be trained that narrow objects that are stationary are light poles or traffic signs.

The machine-learned model can also use voice data collected by the microphone and other context data to determine the identity of nearby individuals. Generally, social-distancing recommendations do not apply to individuals living in the same residence (*e.g.*, parents and young children). The machine-learned model can analyze the voice of individuals near the user to determine whether a nearby individual is someone from the user's residence. If the nearby individual lives in the user's residence, the machine-learned model can filter or exclude this individual from its social-distancing analysis. In this way, the portable electronic device will not provide a false alert. Similarly, the machine-learned model can use location data to determine if the user is within their residence to turn off social-distancing monitoring and alerts.

To reduce the complexity of the analysis, the machine-learned model can use other techniques (*e.g.*, Kalman filters) to track the location and classification of nearby objects. For example, a Kalman filter can be used to monitor the last-known classification and location of an object and predict a future classification and location. Similarly, an initialization routine can be performed by the machine-learned model when the user leaves their residence. The portable electronic device can detect whether the user is accompanied by a pet or another individual and filter this object from the social-distancing analysis.

In addition, the machine-learned model can be trained by users. Users can utilize the user interface to indicate whether social-distancing guidelines are being followed. For example, if the user detects that a person is getting too close (*e.g.*, within six feet or two meters), the user can tap a button to indicate the lack of proper social distancing. In this way, the machine-learned model can be trained to improve its accuracy, calibrate its analysis, and classify new or unusual objects.

The machine-learned model can also utilize data from other portable electronic devices. If other users are using the social-distancing feature, the machine-learned model could obtain social-distancing data from other devices in the user's vicinity to filter out non-human objects and assist with determining the location of other individuals. The crowd-sourcing of local social-distancing information can reduce the complexity and power consumption of the social-distancing feature on each user's device.

If the machine-learned model determines that the user is too close to other individuals, the user is provided an alert (*e.g.*, a vibrating haptic feedback, a visual notification on the display of the portable electronic device). In the navigation application scenario, the OS or application can provide the user with visual alerts that overlap the displayed map to alert users that they are getting too close to other individuals.

The described systems and techniques provide users with real-time social-distancing information to minimize the spread of the coronavirus disease and future pandemics. The portable electronic device can also utilize a machine-learned model to improve detection capabilities, avoid false alarms, and increase accuracy.